NOTES ON THE KAMILAROI STRATIGRAPHY IN THE WESTERN COALFIELD OF NEW SOUTH WALES.

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(Plate ix; four Text-figures.)

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Introduction.

In connexion with an investigation of the stratigraphical arrangement of the torbanite deposits in the Upper Coal Measures of the Kamilaroi Basin of New South Wales, it was found necessary to carry out a limited amount of stratigraphical work along the western margin of the basin, from the Burragorang Valley in the south to the Goulburn Valley in the north (see Index Map, Fig. 1). The principal objects of this work were the determination of horizons representing the upper and lower stratigraphical limits of the Upper Coal Measures, the relation between the Marangaroo Conglomerate Beds and the coal-measures throughout the different districts of the Western Coalfield, and the continuity and arrangement of the principal coal-bearing horizons. Only the upper portion of the Kamilaroi is present in the western districts, consisting of Upper Coal Measures overlying Upper Marine Beds.

A considerable mass of data, obtained by the Geological Survey of New South Wales and other investigators, is available concerning the general stratigraphy of the coal-measures in the Burragorang Valley and the Blue Mountains, and at points between Lithgow, Kandos and Rylstone. Several reports of a reconnaissance nature have been made by the Geological Survey, dealing with the Ulan-Wollar-Barigan coal-measures.

Coal-measures outcropping to the south of the Goulburn River, from Bylong to the vicinity of Sandy Hollow and as far south as Rylstone, have received but little geological attention and have not been surveyed. These coal-measures, together with those of the Ulan-Wollar-Barigan area, should assume importance when the Sandy Hollow-Maryvale railway is completed. In view of these facts and the limited amount of detailed information available concerning the Ulan-Wollar-Barigan area, it was considered essential to include in the present paper a geological map (Plate ix) showing the outcrop of Upper Coal Measure strata and associated formations along the southern side of the Goulburn River between Ulan, Rylstone and Baerami. Numerous igneous bodies in the form of flows, laccoliths, sills and necks occur between Rylstone, Barigan and Kerrabee. These are not shown on the map as their investigation does not come within the scope of the present work.

The Marangaroo Conglomerate Beds.

Beds of conglomerate and sandstone, known as the Marangaroo Conglomerate, have attracted much attention as an important and persistent feature occurring at or near the base of the Upper Coal Measures in the Western Coalfield. Carne (1908) described the Lithgow Coal Seam as the lowest in the Western Coal Measures, occurring immediately above the Marangaroo Conglomerate. This was found to hold good for areas lying immediately to the north and north-east of Wallerawang, but between Marangaroo and Lithgow, the Lithgow Coal Seam occurs directly beneath a thick bed of quartz-pebble conglomerate similar in every respect to the Marangaroo Conglomerate. The same difficulty arose in other districts, the coal-seam appearing sometimes above and sometimes below the conglomerate. A suggested explanation of the relation between the Marangaroo Conglomerate and the Lithgow Coal Seam was put forward by Andrews and Morrison (1926). They considered that there were two stages or members of the

Marangaroo Conglomerate separated by the Lithgow Coal Seam, the upper member being more pronounced to the south and south-east of Marangaroo Railway Siding, and the lower more pronounced to the north and north-west. This explained the apparent anomaly of the Lithgow Seam appearing above the Marangaroo Conglomerate in some places, and beneath it in others.

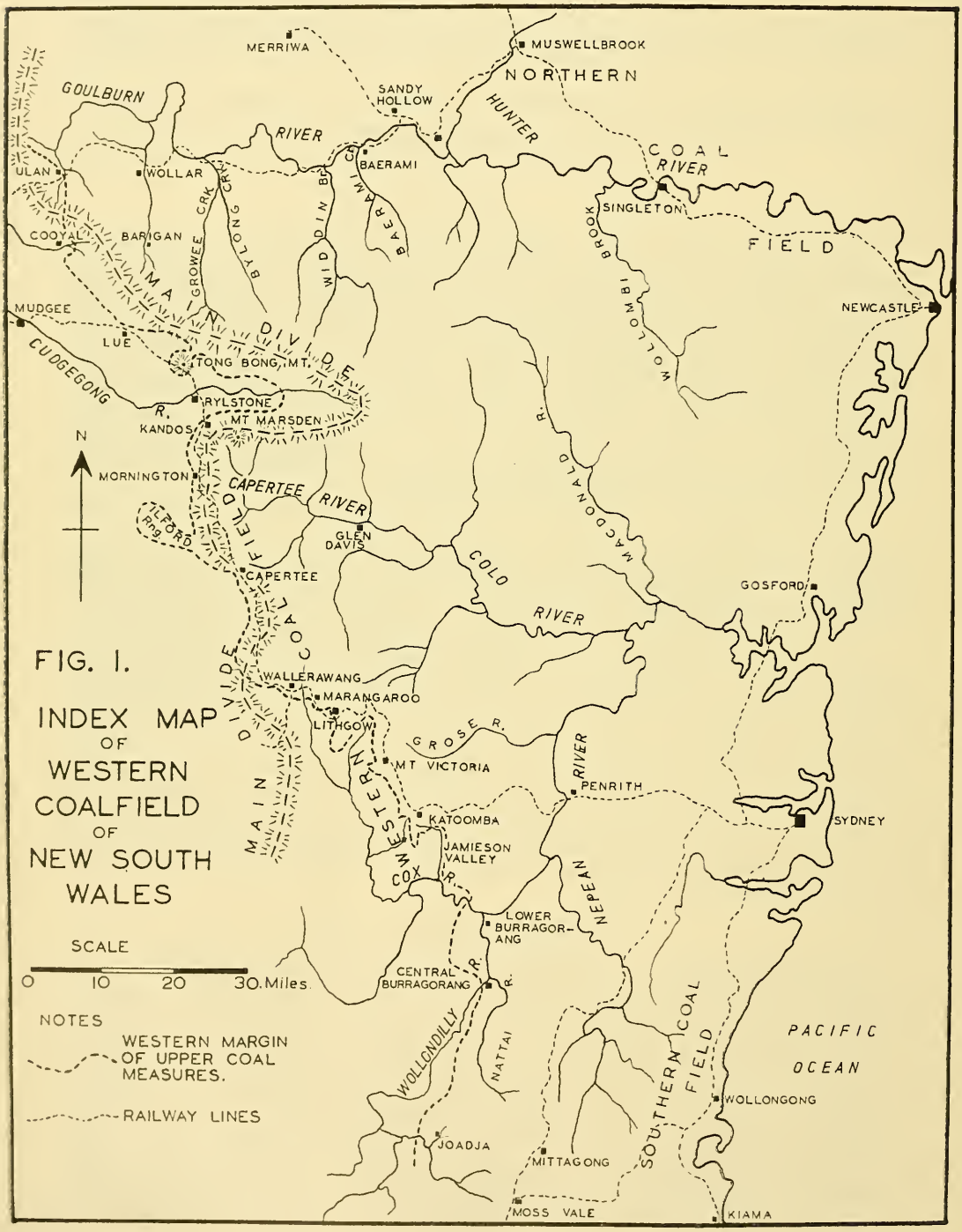

Fig. 1.

For the purpose of description, the two conglomerate beds and the coal-seam will be referred to as the Marangaroo Beds. The relations between these beds have recently been examined by the writer, and the conclusions of Andrews and Morrison have been confirmed in every respect. It has been possible to establish beyond all reasonable doubt, the continuity of the beds from Ulan in the north to the vicinity of Joadja in the south, a distance of 155 miles.

The Marangaroo Beds attain their maximum development in the vicinity of Marangaroo and Wallerawang, where they represent shoreline deposits consisting of coarse quartz-pebble conglomerates. The horizon of the Lithgow Coal Seam is indicated by carbonaceous shale and mudstone in the marginal facies of the Marangaroo Beds, where they outcrop immediately to the north of the point where the main road passes over the old Marangaroo railway tunnel. These shales and mudstone increase in thickness and undergo a gradual change into coal, forming the Lithgow Coal Seam, as they pass to the east. The transition from carbonaceous shale to coal is well shown in the disused railway cuttings about 10 chains south-west from the western end of the new Marangaroo railway tunnel. The general relation between the members of the Marangaroo Beds is illustrated in Fig. 2.

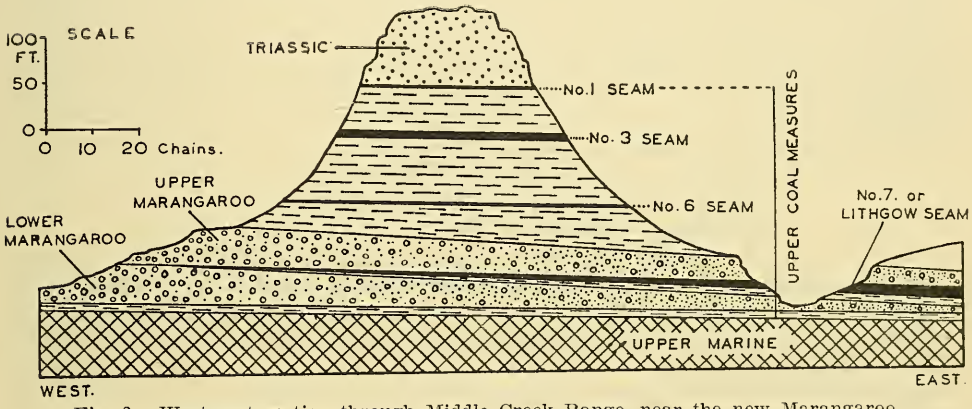

Fig. 2.—West-east section through Middle Creek Range, near the new Marangaroo railway tunnel.

The Marangaroo Beds, consisting of either the upper or lower member, and in places both, together with the Lithgow Coal Seam, constitute a remarkably persistent feature extending throughout the marginal areas of the Western Coalfield. At all places along these marginal areas, which trend from north-west to south-east, the Marangaroo Beds exhibit a rapid lithological change from conglomerate to sandstone and thin out quickly as they pass from west to east, suggesting that the present western margin of the coalfield is approximately parallel to the actual margin of the area in which the beds were deposited.

Between Wallerawang and Capertee, south of the area shown in the map (Plate ix), the lowest member of the Marangaroo Beds maintains its thickness of about 50 feet, while the upper member diminishes and eventually disappears to the north-north-west. The coal-measures outcrop in the Capertee Valley for a distance of about 20 miles east of Capertee before they dip below the level of the Capertee River to the east of Glen Davis, where the lower member of the Marangaroo Beds is present in the form of sandstone 8 to 15 feet in thickness. At places a thin sandstone bed appears above the Lithgow Coal Seam, representing the upper member. At Airly Gap and along the western escarpment of the Capertee Valley the lower member is persistent, forming a sandstone bed from 10 to 20 feet in thickness, but there is very little evidence of the upper member.

At Mornington and north-west to Tong Bong Mountain, the Marangaroo Beds are represented mainly by the lower member, underlying the Lithgow Seam. The upper member becomes more prominent in the vicinity of Mount Marsden, on the northern

side of the Capertee Valley, and continues in a northerly direction, being evident at many places round the head of the Cudgegong Valley. On the northern side of the main divide at the head of Growee Creek, which runs into Bylong Creek (see geological map, Plate ix), both upper and lower members of the Marangaroo Beds are present together with the Lithgow Coal Seam, giving the following section:

20 feet. Sandstone with pebbles. Upper Marangaroo.
5 „ Coal. Lithgow Coal Seam.
4 „ Shales.
8 „ Sandstone. Lower Marangaroo.
6 „ Shales. Followed by Upper Marine.

Growee and Bylong Creeks have eroded their valleys well below the base of the Upper Coal Measures, exposing up to 300 feet of Upper Marine strata. The outcrop of the Marangaroo Beds runs along the sides of these valleys, forming a well-defined feature. Between the junction of Growee and Bylong Creeks and the point at which the Bylong Creek runs into the Goulburn River, the strata assume a strong northerly dip, and the horizon of the Marangaroo Beds passes beneath the floor of the Goulburn Valley. At Wollara Station, about six miles up the Goulburn River from its junction with Bylong Creek, the Marangaroo Beds again outcrop, forming a prominent feature a little above the level of the valley-floor, which is in Upper Marine Beds. On the eastern side of the gap between the Wollar and Goulburn Valleys, through which the road and railway pass, both upper and lower members of the Marangaroo Beds are present, separated by carbonaceous shales and mudstone which occupy the horizon of the Lithgow Coal Seam, as follows:

15 feet. Coarse sandstone. Upper Marangaroo.
3 „ Carbonaceous shale. Horizon of Lithgow Seam.
4 „ Shale and mudstone.
20 „ Sandstone. Lower Marangaroo.

In the Wollar Valley the Marangaroo Beds outcrop on either side of the creek, exposing Upper Marine strata, between Barigan and the village of Wollar. To the north of Wollar all the Kamilaroi Beds dip beneath the creek level. Limited outcrops of the Marangaroo Beds and Upper Marine strata also occur in the valley of Willpinjong Creek, a large western tributary of the Wollar Creek. In this locality the upper member is 15 feet thick and the lower about 5 feet, the two forming sandstone beds separated by the Lithgow Coal Seam, which contains some bituminous coal at this point.

In the vicinity of Ulan, on the western margin of the Upper Coal Measures, the Marangaroo Beds become conglomeratic, especially the lower member, which varies from 15 to 25 feet in thickness, and lies directly on the granite forming the basement rock of the Kamilaroi Basin in this locality. The Lithgow Seam attains the remarkable thickness of 30 feet, consisting mainly of good coal with a number of thin chert bands, and the upper member of the Marangaroo Beds is 35 feet thick and much finer grained than the lower. The typical Upper Marine Beds of sandy shale and mudstone with calcareous bands, are overlapped by the lower member of the Marangaroo somewhere between Ulan and the Willpinjong Valley.

From Ulan the margin of the Kamilaroi trends roughly south-east through Cooyal and Lue to Rylstone. About 5 miles from Ulan, Upper Marine Beds again outcrop between the Marangaroo Beds and the old Palaeozoic basement rocks. Between Cooyal and Lue, the lower member of the Marangaroo Beds outcrops strongly as a bed of sandy conglomerate from 30 to 50 feet in thickness. The Lithgow Coal Seam is very inconstant, forming up to 7 feet of coal at some places and nothing but coaly streaks in carbonaceous shale at others. The upper member of the Marangaroo is less conspicuous than the lower, being fine-grained and seldom amounting to more than 10 feet in thickness. Passing to the east from Lue towards Rylstone, the lower member loses its conglomeratic nature and becomes reduced in thickness to about 10 feet at Tong Bong Mountain. The Lithgow Seam is more persistent, with a thickness of about 5 feet of coal, and the upper member of the Marangaroo appears to cut out almost completely.

South-east from Marangaroo and Wallerawang, the lower member of the Marangaroo Beds diminishes rapidly in thickness and becomes inconspicuous in the vicinity of

Lithgow. For detailed descriptions and sections of the Marangaroo Beds and Lithgow Coal Seam in the Lithgow district, see Carne (1908), Andrews and Morrison (1926), Andrews (1928). On the western side of the valley of the Lett River both members of the Marangaroo Beds are present as sandstone occurring above and below the Lithgow Coal Seam, the upper member being 9 feet in thickness and the lower 12 feet. On the eastern side of the Lett River Valley in the vicinity of Hartley Vale, the lower member becomes less prominent and the upper member consists of sandy conglomerate overlying the Lithgow Seam. In the Grose Valley, to the east of Hartley Vale, the upper member and Lithgow Seam outcrop at several places but there is little evidence of the lower member. South of Hartley Vale in the vicinity of the Victoria Pass and Sugar Loaf Mountain, the upper member forms the roof of the Lithgow Seam and varies in thickness up to 20 feet. The lower member outcrops on the eastern side of Sugar Loaf Mountain where it is 23 feet thick, but it appears to be non-existent on the north-western side at Hartley Pass Colliery and Victoria Pass.

Between Mount Victoria and Blackheath the upper member persists as sandy conglomerate and coarse sandstone varying between 10 and 20 feet in thickness, and the lower member occurs at isolated points only. Under the western escarpment of Mount Blackheath the upper member forms 9 feet of sandstone overlying the Lithgow Coal Seam, but there is no evidence of the lower member. To the south-east of Blackheath in the vicinity of the Megalong Valley, both members of the Marangaroo Beds are present in the form of coarse sandstone containing numerous small white quartz pebbles. At the western head of Nellie's Glen the upper and lower members are 12 and 10 feet thick respectively, and the Lithgow Seam consists of about 6 feet of carbonaceous shales with bands of bituminous coal. On the eastern side of Megalong Valley, at Mort's Glen Mine, the following section is exposed at several places:

8 feet. Fine quartz-pebble conglomerate. Upper Marangaroo.
4 inches. Bright bituminous coal. Lithgow Coal Seam.
3 feet. Shales.
6 feet. Fine quartz-pebble conglomerate. Lower Marangaroo.

Considerable difficulty was experienced in following the outcrop of the Marangaroo Beds to the south-east of Katoomba, owing to the heavy covering of talus along the steep and rugged sides of the Jamieson Valley. Sufficient outcrops were obtained, however, to establish the continuation of the beds along the eastern side of the valley, and at a point about three miles from its junction with the Cox Valley, good sections are available showing both upper and lower members forming beds of pebbly sandstone, 15 and 10 feet thick, respectively, and separated by 5 feet of carbonaceous and coaly shale representing the Lithgow Coal Seam. The extension of the beds to the east, along the Cox Valley, was established by sections obtained at a number of points. At the junction of the Cox and Wollondilly Rivers, the following section was measured:

20 feet. Sandstone. Upper Marangaroo.
2 „ Coaly shale. Lithgow Coal Seam.
13 „ Shales.
3 „ Black mudstone.
15 „ Coarse sandstone. Lower Marangaroo.

The presence of the Marangaroo Conglomerate and Lithgow Coal Seam in the Lower Burragorang Valley was reported by Morrison and Kenny (1924) at Brimstone and Riley's Gullies on the eastern side of the valley. The writer obtained a section near Mount Kamilaroi, at the junction of the Nattai and Wollondilly Rivers, showing 10 feet of upper Marangaroo sandstone, 4 feet of coaly and carbonaceous shales representing the Lithgow Coal Seam, and 20 feet of pebbly sandstone constituting the lower Marangaroo. Further to the south-west at Higgins Creek, near Mount Tonalli on the western side of the Burragorang Valley, an exposure first recorded by Morrison and Kenny (1932) shows the Lithgow Seam consisting of 10 feet of coal, and 8 feet of conglomerate forming the lower Marangaroo.

The beds can be followed along the eastern side of the Upper Burragorang Valley, where sections were originally measured by A. J. Lambeth. The lower member of the Marangaroo Beds, varying between 10 and 20 feet in thickness, assumes a conglomeratic

nature similar to that of the types developed between Capertee and Wallerawang. The Lithgow Seam is of very variable nature, consisting of coal in some places and carbonaceous shale in others, and the horizon of the upper Marangaroo is occupied mainly by a sandstone bed from 10 to 15 feet in thickness. Much the same situation exists at the southern end of the Burragorang Valley near Bullio, where the lower member consists of a well-marked conglomerate.

The southern continuation of the Marangaroo Beds is established by a section in the Joadja Valley first reported by Carne (1903), where the Lithgow Seam, 4 feet in thickness, overlies a massive conglomerate 15 to 20 feet in thickness, constituting the lower Marangaroo. South from Joadja the lower member thins out rapidly but maintains its conglomeratic nature. A section measured at Penang Trig. Station by A. J. Lambeth shows 9 feet of heavy conglomerate, and carbonaceous shales on the horizon of the Lithgow Seam. South from Penang, the lower member has been followed to the vicinity of Emu and Black Bob's Creeks on the southern side of the Wingecarribee River.

The lower member of the Marangaroo Beds appears to extend some distance to the east from the Upper Burragorang Valley, as indicated in a section obtained by David (1889) on Iron Creek near Colo, where the Lithgow Seam, consisting of 6 feet of coal, immediately overlies a bed of conglomerate representing the lower Marangaroo.

The Occurrence of Coal-Measures below the Marangaroo Beds near Bylong.

Coal-measures are not known below the thin bed of shales immediately underlying the lower member of the Marangaroo Beds, with the exception of one occurrence in the Goulburn Valley, two miles up the river from its junction with Bylong Creek. At this point, below the road at the eastern end of a cutting in the steep southern bank of the river, 80 feet of coal-measure beds, including three coal seams, outcrop between the bed of the river and the lower member of the Marangaroo, as illustrated in Fig. 3. The base of the beds is not exposed, so they must be over 80 feet in thickness. The outcrop extends over a small area on the floor of the valley (see geological map, Plate ix), but

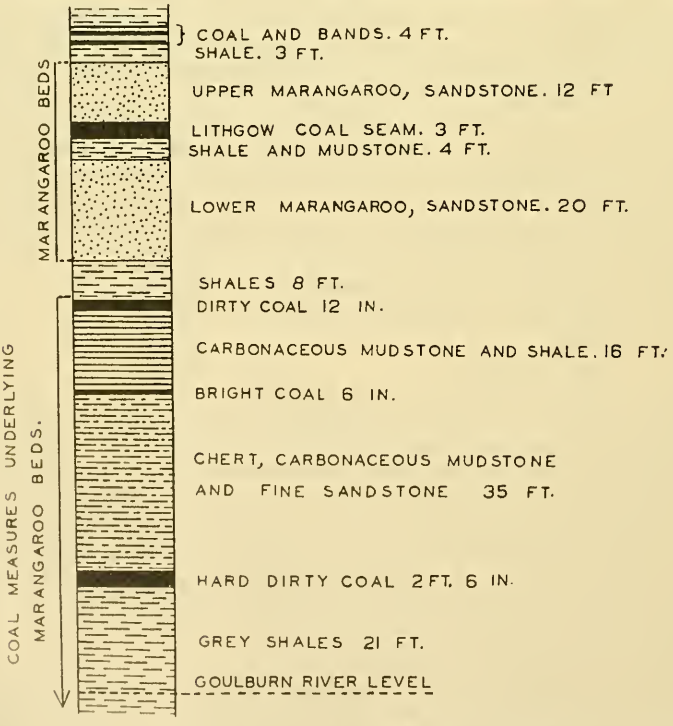

Fig. 3.—Section of coal-measures underlying Marangaroo Beds near Bylong.

cannot be traced for more than one mile to the west; here the Upper Marine again assumes its normal position below the Marangaroo Beds which evidently overlap the intervening coal-measures. To the east the strata dip beneath the bed of the river, and the Marangaroo Beds do not outcrop again in the Goulburn Valley.

These coal-measures may be a local development representing an isolated deposit, but it seems highly probable that they are the equivalent of some section of the coal-measures outcropping in the Hunter Valley, with which they may be continuous, the exposure described being on the actual margin of a unit thinning out towards the west. It is evident that the coal-measures occur between the Marangaroo Beds and the Upper Marine, and thus they cannot be equivalent to the Greta or Lower Coal Measures, but most probably represent the lower portion of the Newcastle Stage, or possibly the upper portion of the Tomago Stage of the Upper Coal Measures in the Hunter Valley. Taken in conjunction with the enormous increase in thickness of the Upper Coal Measures, amounting to about 3,000 feet, which occurs between the western districts and the Hunter Valley, the foregoing results would indicate that the horizon of the Marangaroo Beds occurs well above the base of the Upper Coal Measures in the Northern Coalfield. Furthermore the increase in thickness of the coal-measures is evidently due to the coming in of additional beds towards their base, as well as an increase in the thickness of the measures which outcrop in the western districts.

The Upper and Lower Stratigraphical Limits of the Upper Coal Measures.

Along the western margin of the Kamilaroi Basin, Triassic sandstone overlies beds of the Upper Coal Measures, which in turn rest on Upper Marine strata. These three formations are conformable, and considerable difficulty has been experienced in determining specific horizons representing the base and upper limits of the coal-measures. At the base of the measures the general change in sedimentation was from marine to freshwater conditions, while at the top it involved the passing from Permian to Triassic time.

Carne (1908), after considering the evidence available at that time, came to the conclusion that the Marangaroo Conglomerate, immediately overlying the Lithgow Coal Seam, should be taken as an arbitrary base of the coal-measures, representing an approximate line of division between the underlying marine sediments and the overlying freshwater beds.

As stated earlier in this paper, it has been established that there are two members of the Marangaroo, occurring immediately above and below the Lithgow Coal Seam. It has been noted by the writer that small seams of coal, usually amounting to less than 12 inches in thickness, frequently occur on top of the upper member of the Marangaroo Beds, and also just below the lower member. Those occurring below the lower member are invariably associated with carbonaceous shales which vary in thickness up to 10 feet, and contain *Glossopteris*. Below these shales occur the typical Upper Marine Beds, consisting of fine grits, sandy mudstones, calcareous shales and mudstone, and in places sandy conglomerate with angular pebbles and erratic boulders up to 18 inches in diameter. Although fossil evidence is difficult to obtain in these beds, they are certainly marine and probably fluvio-glacial, and form the topmost beds of the Upper Marine Series. At one place between Lue and the head of Cooyal Creek, the lower member of the Marangaroo is separated by 3 feet of shale from a rather remarkable tillite, consisting of a hard matrix and extremely angular fragments up to 12 inches in length.

Figure 4 is a generalized form of the sequence exposed at many places along the margin of the Western Coalfield. With the one exception described above, no shales resembling freshwater sediments or containing coal-measure fossils have been found lower than the few feet of shales occurring immediately below the lower member of the Marangaroo. The nature of the Marangaroo Conglomerates, their proximity to the Upper Marine Beds, and the fact that coal-measure shales and coal are interbedded with them, create the impression of a fluctuating transition from glacial marine to warm freshwater conditions of sedimentation. This cannot be so, however, as normal Upper Coal Measure strata occurring betweeen the Marangaroo Beds and the Upper Marine in the Goulburn Valley, exclude the possibility of the Marangaroo Conglomerates being

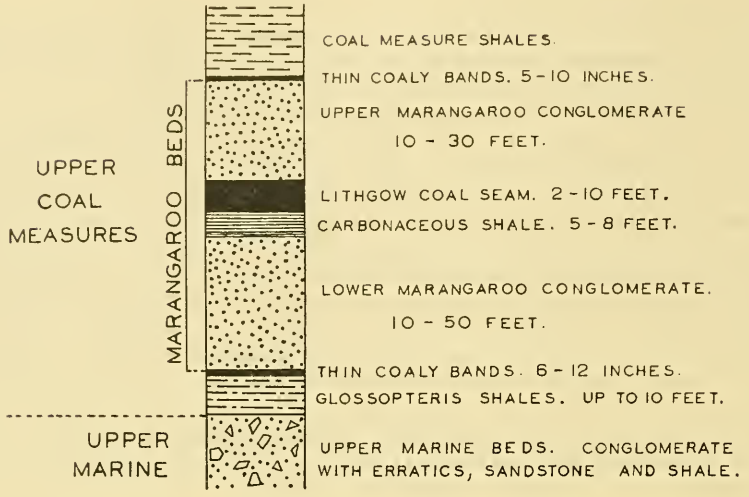

Fig. 4.—Generalized section at base of Upper Coal Measures.

passage beds. It follows that the top portion of the Upper Coal Measures, including the horizon of the Marangaroo Beds, overlaps the lower portions between the Hunter Valley and the western districts, and lies directly on the Upper Marine. This would involve a long time-break, preceding the deposition of the Marangaroo Beds, and considerable contemporaneous erosion would be expected at the top of the Upper Marine. Such erosion is suggested by the fact that the topmost beds of the Upper Marine vary from tillite to sandstone and shales, at different places along the western margin of the coal-measures. In view of the foregoing, it is evident that the thin bed of shales occurring between the lower member of the Marangaroo and the typical Upper Marine strata, must be taken as the base of the Upper Coal Measures.

The coal-measures are overlain by the Narrabeen Beds of the Triassic Series, carrying residual masses of Hawkesbury Sandstone at many places along the central western margin of the Kamilaroi Basin. The Narrabeen Beds are characterized by massive sandstone, with "chocolate shales" occurring on several horizons. The Triassic sandstone weathers into bold cliffs which contrast with the talus-slopes of the underlying coal-measures. The approximate junction between the two formations occurs at or near the base of the cliffs, but the determination of the actual horizon by means of which they may be separated presents some difficulty. As described by Carne (1908), there is no apparent break in the stratigraphical sequence from Kamilaroi to Triassic, but a time-lapse is indicated by a sudden change in the types and relative abundance of fossil flora, which occurs immediately above the top or Katoomba Coal Seam. The relation between the Upper Coal Measures and Triassic in other parts of the Kamilaroi Basin has been discussed by David (1907), Dun (1910), Harper (1915) and Raggatt (1938).

The writer has recently investigated the relationship along the western margin of the Kamilaroi Basin. From the Goulburn River in the north to the Lower Burragorang Valley in the south, the Katoomba Coal Seam occupies a horizon near the base of the massive Triassic sandstone, which forms vertical cliffs. The depth of the coal-seam below this sandstone varies from nothing to about 70 feet. The intervening space, where present, is occupied by shales or laminated shaly sandstone. In some places these shales thin out towards the points where the coal-seam is in contact with the sandstone, while elsewhere they change gradually from shale to shaly and laminated sandstone, then finally pass into massive sandstone. Typical coal-measure fossils such as *Glossopteris* and *Vertebraria* are abundant in the beds underlying the Katoomba Seam, and in the seam itself, but they were not found in the shales and laminated sandstone immediately overlying the coal-seam, where the only fossils observed were *Phyllotheca*

and fragmentary plant debris. In other parts of the Kamilaroi Basin, *Glossopteris* is said to be associated with Mesozoic flora close above the top seam (Carne, 1908).

The foregoing evidence would indicate that the change from Permian to Triassic strata occurs immediately above the Katoomba Coal Seam, but the sudden disappearance of *Glossopteris*, and the entry of Mesozoic flora at this horizon would also indicate a considerable time-break during which sedimentation ceased. This being so, it is difficult to understand the conditions which allowed the preservation of plant-material, and the early stages of coalification, to proceed over the extensive area now occupied by the top seam, with only the thinnest veneer of sediments covering it. The absence of contemporaneous erosion is particularly marked at the horizon of the coal-seam, and it seems unlikely that extensive removal of protecting sediments could have taken place during the apparent time-lapse in sedimentation between the two periods. In view of this difficulty, it seems most likely that some relatively sudden change in environmental conditions occurred after the deposition of the coal-seam, exterminating the *Glossopteris* flora almost completely. Sedimentation probably continued at a very slow rate depositing transition beds while the first Mesozoic plants made their appearance. Then the more rapid deposition which produced the massive Triassic sandstones may have caused contemporaneous erosion some distance above the coal-seam in marginal areas. This erosion could be responsible for the variation in thickness, and irregular nature of the shaly transition beds between the coal-seam and the massive sandstone.

In consideration of the foregoing evidence and discussion, the most accurate and suitable line of demarcation between Triassic and Kamilaroi Beds, for those areas north of Central Burragorang, would be a horizon immediately above the Katoomba Seam. South from Central Burragorang, to the vicinity of Joadja and Mittagong, a somewhat different situation exists. In this area the top portion of the Upper Coal Measures is missing, and the No. 3 or Dirty Seam becomes the top seam, taking the place of the Katoomba Seam in the Western Coalfield. This has been referred to in publications of the Department of Mines (Morrison and Kenny, 1924; Jones, 1925; Andrews, 1928), and substantiated by detailed work recently carried out by A. J. Lambeth in the area concerned. The writer has also followed the Dirty Seam from the vicinity of Katoomba to Central Burragorang where it forms the top seam of the coal-measures. It is important that the Dirty Seam in the Burragorang-Joadja district bears much the same relations to the Triassic as the Katoomba Seam in the Western Coalfield. Thus the time-break between the deposition of the Dirty Seam and the massive Triassic sandstone must have been much longer than that which followed the formation of the Katoomba Seam. *Glossopteris* is common in the shales occurring between the Dirty Seam and the Triassic sandstone, and it is probable that considerable contemporaneous erosion occurred before the commencement of Triassic time. It follows that the line of subdivision between Triassic and Kamilaroi in this area must be taken at the base of the massive sandstone or the highest horizon on which coal-measure fossils are found, and not necessarily at the top of the highest coal-seam.

The Continuity and Arrangement of Coal-Bearing Horizons.

In the following notes the coal-seams, and horizons on which they occur, are described in terms of their importance as stratigraphical units. For information concerning their relative importance in the coal mining industry, reference should be made to Carne (1908), Pittman (1912), Jones (1925, 1926), Andrews and Morrison (1926), and Andrews (1928).

The No. 1, or Katoomba, Seam, as already described, occupies the highest position in the coal-measures. Its horizon is well defined either by a coal-seam or by coaly bands and carbonaceous shales, and can be identified at almost all points in the western districts. The horizon occupies from 5 to 20 feet of strata, although there is seldom more than 6 feet of good coal in any one section. In the vicinity of Capertee Valley and Rylstone, splits in the seam are common. At Ilford Range, Mornington and Mount Marsden, a bed of chert splits the seam into upper and lower portions, and in the vicinity of the Ilford Range the lower portion is split by numerous bands of shale, giving a total thickness of 22 feet for the whole coal-bearing zone. The horizon is very persistent and free from washouts, and there is much less evidence of thinning and

irregularities towards the margin of the measures than in the case of some of the lower horizons. One exception to this occurs in the vicinity of Ulan, where the Katoomba horizon is missing altogether over a considerable distance to the east of the Ulan Coal Mine, having been overlapped by the Triassic. It is present, however, in the Willpinjong Valley, 8 miles to the east of Ulan, where it consists of 5 feet of coal and bands, and has been followed along the southern side of the Goulburn River to Baerami, near Sandy Hollow. As described above, in the south-western districts between Burragorang and Joadja the coal-measures above the Dirty Seam are missing. The most southerly point at which the Katoomba horizon has been observed, is in the Burragorang Valley at Mount Kamilaroi near the junction of the Nattai and Wollondilly Rivers.

The second coal-bearing horizon, or No. 2 Seam, is very inconstant and occurs only at isolated points in the western districts. It is missing altogether in the Burragorang-Joadja area, as described in the literature dealing with the absence of No. 1 Seam in that locality. It is present in the Cox Valley, a little above the junction of the Cox and Wollondilly Rivers, and has been followed to the Jamieson Valley, where it occurs 25 to 35 feet below the Katoomba Seam. It is present at Katoomba and continues intermittently to the vicinity of Lithgow, where it is 25 to 40 feet below the top seam. To the north of Lithgow there is very little evidence of the No. 2 horizon. At one or two places in the Capertee Valley thin bands of coal have been observed at from 20 to 30 feet below the Katoomba Seam, but in the coal-measures between Ulan, Bylong and Rylstone, the No. 2 Seam appears to be completely absent. Further to the east, however, in the Baerami and Widdin Valleys, a coal-seam varying in thickness up to 4 feet occurs about 35 feet below the top seam and 55 feet above the Dirty Seam, and may be equivalent to the No. 2 horizon.

The third coal-bearing horizon, on which the No. 3 or Dirty Seam is developed, is one of the most important and consistent stratigraphical units occurring in the Western Coalfield. It is marked by a zone of strata varying from 10 to 40 feet in thickness and is characterized by numerous bands of shale and chert interbedded with coal. It is possible to find this horizon at all points on the coal-measure slopes where exposures of the strata occur. It is continuous from the Burragorang-Joadja area, where it occurs at the top of the measures, to the Goulburn Valley in the north, and it has been followed east along the southern side of the Goulburn Valley and its tributaries, to Baerami. West from Wollar, the No. 3 horizon thins out considerably, and it is absent over small areas in the vicinity of the Ulan Coal Mine, on the actual margin of the coal-measures.

The No. 3 horizon usually occurs less than 100 feet below the Katoomba Seam, the average depth being about 75 feet. It has been noted that this interval does not necessarily vary as a function of the total thickness of the coal-measures. At Katoomba, No. 3 is 60 feet below the No. 1 Seam where there is a total thickness of about 300 feet of coal-measures, while at Glen Davis the interval is 63 feet with a total of 580 feet, and at Tong Bong Mountain it is 70 feet, where the coal-measures are only 240 feet in thickness.

The three coal-bearing horizons just described can be correlated with the three highest coal-seams of the Southern Coalfield. The same applies to the lowest coal-seam in the measures, known as the Lithgow Seam in the western districts and No. 7 Seam on the south coast of New South Wales. There is some difficulty, however, in correlating Nos. 4, 5, and 6 of the south coast with equivalent horizons in the Western Measures. Small and unimportant seams of coal occasionally appear on two horizons which may be equivalent to Nos. 4 and 5, but they are of no value industrially, and do not form persistent stratigraphical horizons.

The Irondale Seam or No. 6, occurring above the Lithgow Seam, is generally considered to be equivalent to No. 6 on the south coast. Its horizon is well marked and continuous in the vicinity of Lithgow, Capertee Valley and Kandos, but further to the north it is not possible to follow it continuously. Between Katoomba and Lower Burragorang the No. 6 horizon becomes indefinite, although it is believed that the middle seam of the three which occur in the Burragorang-Joadja area, is its equivalent. In the central portion of the Western Coalfield, the Irondale Seam occurs at a height

varying between 70 and 180 feet above the Lithgow Seam, and at a depth of 80 to 200 feet below the Dirty Seam. Its relative position is reasonably constant, the variation in the above figures being due to differences in the thickness of the measures between the Dirty and Lithgow horizons.

The No. 7, or Lithgow, Seam is an important stratigraphical horizon. Its relationship to the Marangaroo Conglomerates at the base of the coal-measures, and typical increase in thickness as it passes away from the marginal areas of the coal basin, are described above. The No. 7 horizon occupies from 5 to 20 feet of strata, consisting of coal, carbonaceous shale and mudstone. At many places near the margin of the measures, the horizon bears only carbonaceous shale and mudstone with coaly bands, although an important coal-seam is present in several districts, amounting to 10 feet in the vicinity of Lithgow and the exceptional thickness of 30 feet at Ulan. The coal-seam, where present, almost invariably occurs at the top of the No. 7 horizon, immediately underlying the upper member of the Marangaroo Beds.

From Ulan to Bylong, the Lithgow Seam gradually decreases in thickness from 30 to 2 feet, thus forming a rather striking exception to the usual thickening of the seam as it passes to the east away from the margin of the measures. To the south-east from Ulan, the coal-seam on the No. 7 horizon rapidly decreases in thickness and assumes an irregular nature between Cooyal and Rylstone, some exposures showing only a few inches of coal and others as much as 8 feet. From Rylstone to Bylong the seam is also irregular, seldom amounting to more than 6 feet of coal, and consisting of nothing but carbonaceous mudstone in many places.

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